Identification and Control of Honey Bee Diseases

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CONTENTS

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IDENTIFICATION AND CONTROL OF HONEY BEE DISEASES

By H. Shimanuki, *ARS microbiologist* [1]

Bee diseases are present throughout the United States. They are responsible for large annual losses in bees, honey, and equipment, and add greatly to the cost of production. Also, the loss of pollinating bees results in a lower yield of seed and fruit.

Bee diseases should be detected in their early stages; prompt treatment will prevent their spread. (See box on sending diseased samples for diagnosis on page 13.) Contagious diseases spread quickly within a colony, and the crowding of colonies increases the possibility of the spread of diseases from hive to hive. When searching for disease symptoms be aware that a colony may have more than one disease.

It is especially important that the two most serious brood diseases—American foulbrood and European foulbrood—be detected early. Make routine inspections for these diseases.

BROOD DISEASES

To identify brood diseases, carefully examine dead brood found in the cells. The appearance of the combs may indicate which brood disease is present, but final diagnosis depends on the symptoms shown by the dead brood.

Dead brood in open cells of a comb can be seen clearly if the comb is inclined so that direct sunlight falls on the lower side of the cells. If you do not find any dead brood in the open cells, remove sunken, discolored, or punctured cappings and examine them for dead brood.

When you examine dead brood, observe its appearance and position in the cells. Note its age, color, consistency, and odor. For example, if the affected brood is unsealed in the comb then European foulbrood is suspected. If only the sealed brood is affected, and has collapsed into a ropy brown mass, American foulbrood is suspected.

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American Foulbrood

Cause

American foulbrood, the most widespread and most destructive of the brood diseases in the United States, is caused by a spore-forming germ known as *Bacillus larvae*. Adult bees are not affected by this disease.

Only the spore stage of *Bacillus larvae* is infectious to honey bees. All castes of honey bees are susceptible to the disease, but worker larvae are particularly susceptible. However, larvae become immune to the disease about 3 days after the egg hatch.

Effect

Only a few dead larvae or pupae will be seen when the colony is first infected by the disease. Occasionally, enough larvae become infected to weaken or kill the colony the first season. On the other hand, the disease may not develop to the critical stage until the following year. If left unchecked, American foulbrood quickly spreads to healthy colonies in nearby apiaries.

Symptoms

If American foulbrood is infecting your colony, the cells of your brood comb will have a scattered and irregular pattern of capped and uncapped cells, and cells with sunken and punctured cappings. This "pepperbox" appearance will contrast with the entirely sealed cells of a healthy brood comb. (See fig. 1.)

A larval color change is one of the signs of infected larvae. Dying larvae gradually change from pearly white to dark brown. The "pepperbox" pattern begins to form as the larvae shrink; the capping is drawn down into the cell so that the normally convex capping becomes concave. In advanced stages of the disease many of the cappings are punctured. (Cappings over dead brood are often removed by adult bees.)

The decay and drying of dead brood takes a month or more. The larvae remain dry and later form a brittle scale that adheres to the lower wall of the cell. (See fig. 2.)

One way to verify that American foulbrood is causing larval death is to remove and examine some of the decayed larvae from the brood cells. During the early stages of decay, about 3 weeks after death, the body wall of the cell can be easily ruptured. Using a toothpick or matchstick, thrust into the decayed larvae and withdraw the decaying mass. If the disease is present, an inch or more of brown, gluelike thread can be withdrawn. This condition is known as the "ropy stage." (See fig. 3.)

When the remains begin to turn brown and become ropy, an odor can be detected that is typical of the advanced stages of this disease. This same odor persists even when the scales are formed.

Larvae often develop into pupae before death occurs. Pupae undergo the same changes in color and consistency as larvae.

When a pupa dies from American foulbrood its tongue generally protrudes from the scale to the center of the cell. (See fig. 4.) This symptom is characteristic

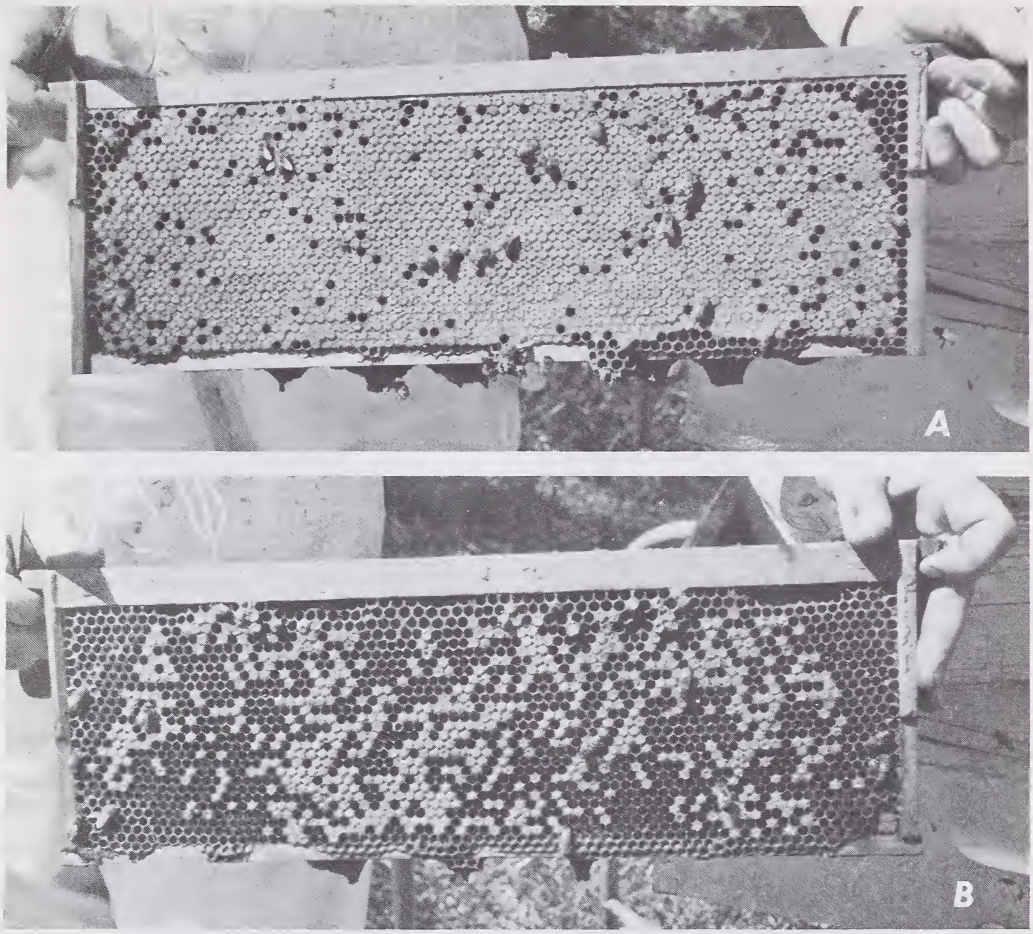

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Figure 1. Brood combs showing (A) healthy brood necessary for high honey production, and (B) diseased brood, which results in weakened colonies and low honey production.

only of pupae infected by American foulbrood. It should not be confused with the short blunt protrusion—or "false tongue"—associated with European foulbrood.

Spread

American foulbrood can spread in a colony when—

- Nurse bees transmit bacillus spores to young larvae.
- Honey is stored in cells that once contained diseased brood.
- Bees are exposed to contaminated honey.
- Equipment is used for both diseased and healthy colonies.

Nurse bees can inadvertently feed bacillus spores to young larvae. Soon after the larva has been sealed in its cell, or just after it changes to a pupa, the spores will germinate in the gut of the larva and multiply rapidly, causing death. New spores will form by the time the larvae dies. When the house bees clean out

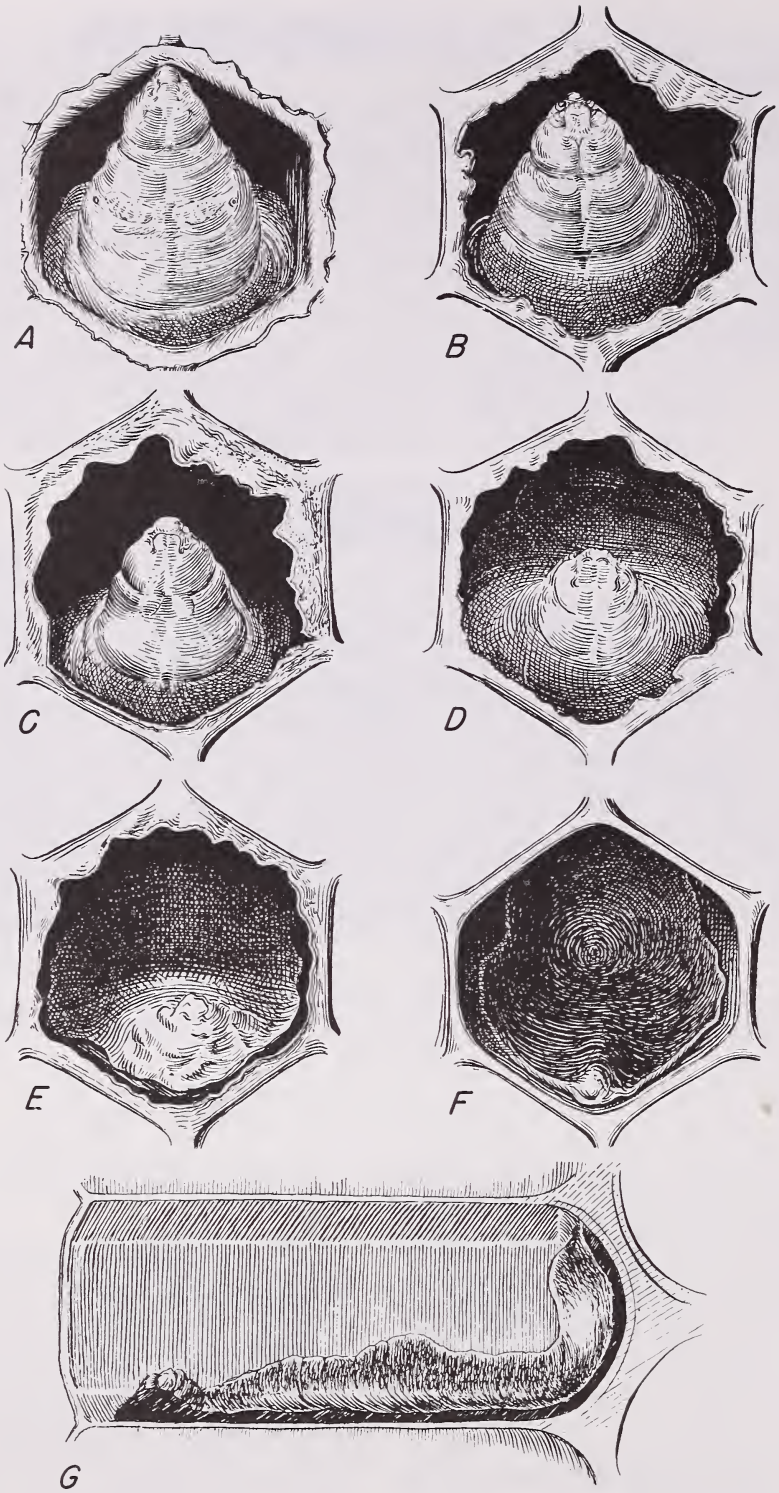

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Figure 2. Honey bee larvae killed by American foulbrood, as seen in cells: (A) Healthy larva at age when most of brood dies of American foulbrood; (B-F) dead larvae in progressive stages of decomposition (remains shown in F are scale); (G) longitudinal view of scale.

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Figure 3. One way to determine whether or not American foulbrood is causing larval death is to remove and examine decayed larvae from the brood cells. Here, removal of a gluelike thread, known as the "ropy stage," proves the disease is present.

the cell containing the dead larva, spores will be distributed throughout the hive, thus infecting more larvae.

Honey stored in cells that once contained diseased brood becomes contaminated and may be fed to susceptible larvae. As the infection weakens a colony, the colony cannot defend itself from robber bees from strong colonies. The robber bees take the contaminated honey to their own colony and repeat the cycle of infection and robbing.

When bees are exposed to contaminated honey, or the same equipment is used for diseased and healthy colonies, there is a danger of disease spread. Therefore, it is extremely important that diseases are detected in their early stages, and that equipment is free from disease organisms.

Control

No commonly used strains of honey bees are immune to American foulbrood.

Burning. — When American foulbrood is discovered in your apiary the diseased colonies should be destroyed by burning. Before you burn diseased colonies, however, you must dig a pit to hold the burned material.

Dig a pit 18 inches or more in depth and wide enough to hold all the material to be burned. Situate the pit in a place not likely to be disturbed.

Immediately after all the bees have been killed, place the hive on pieces of burlap or strong paper; this will make it easier to gather up and burn the bits of comb, honey, or dead bees. Do this quickly to reduce the possibility of robber bees spreading the disease to healthy colonies.

When burning the colony, kindle a fire beneath it with cross members strong enough to support the weight of the frames. Allow plenty of ventilation. A brisk, hot fire is necessary to quickly burn the brood and honey.

Do not burn the bottom boards, hive bodies, inner covers, or outer covers. These items should be scraped to remove all bee glue (propolis) and wax, and then scrubbed with a stiff brush and hot soap solution. Afterward, dispose of the wash water and burn the scrapings so they are not accessible to bees.

The scraping and scrubbing procedures above *will not* sterilize the bee equipment. To do this, completely immerse your equipment for 20 minutes in a boiling lye solution (sodium hydroxide) containing 1 pound of lye to 10 gallons of water. Wooden parts can be damaged by longer exposure. Weaker solutions may not remove all the wax and propolis from the hive equipment.

Remember that lye solutions are caustic and can cause severe burns. Before using the lye, read the label carefully and observe all precautions.

Treatment.—The burning of diseased colonies in the apiary gets rid of only those colonies in which American foulbrood is present in an active form. To prevent the spreading of the disease throughout the apiary, and to control it, oxytetracycline (Ter-

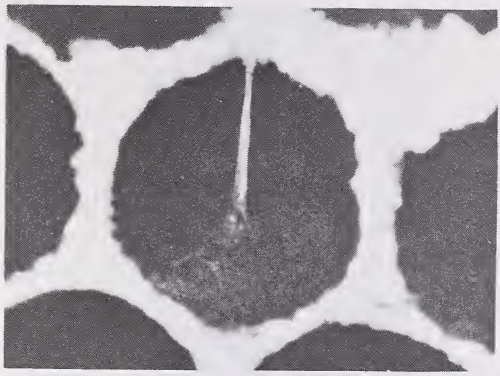

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Figure 4. Pupal tongue from honey bee pupae killed by American foulbrood protrudes from the scale to the center of the cell.

ramycin) has been used. Labels for drugs carry specific instructions for their application, subject to State laws and regulations. Consult with State apiary inspectors, extension apiculturists, or State entomologists before using any chemicals.

European Foulbrood

Cause

European foulbrood is caused by the germ *Streptococcus pluton*. These lancet-shaped bacteria are usually present in large numbers in sick and recently dead larvae.

European foulbrood is found all over the world; in some areas it is considered far more serious than American foulbrood.

Effect

All castes of bees are susceptible to European foulbrood, although differences in susceptibility can be found in various stocks.

European foulbrood is most common in the late spring. This is a period when brood rearing is at its height, although the earliest brood is rarely affected.

Sometimes the onset of the disease is quite subtle and difficult to detect. It spreads slowly through the colony with little apparent damage. In severe cases, however, colonies are seriously weakened.

The disease usually subsides by midsummer, but it occasionally stays active through summer and fall. Sometimes the disease subsides in the summer and reappears in the fall. A good honey flow hastens recovery.

Symptoms

In European foulbrood the "pepperbox" pattern of capped and uncapped cells develops only when the disease attains serious proportions. Unlike American foulbrood, most of the larvae die before their cells are capped. However, you can sometimes observe discolored, sunken, or punctured cappings.

The most significant symptom of European foulbrood is the color change of the larvae. They change from normal glistening white to a faint yellow. Larvae also lose their plump appearance and appear undernourished.

Most larvae die while in the coiled stage. (See fig. 5.) When the larvae become brown their white tracheal system becomes visible. The diseased larvae sometimes appear to collapse from their upright state. In such cases larval remains appear twisted or melted to the bottom of the cell.

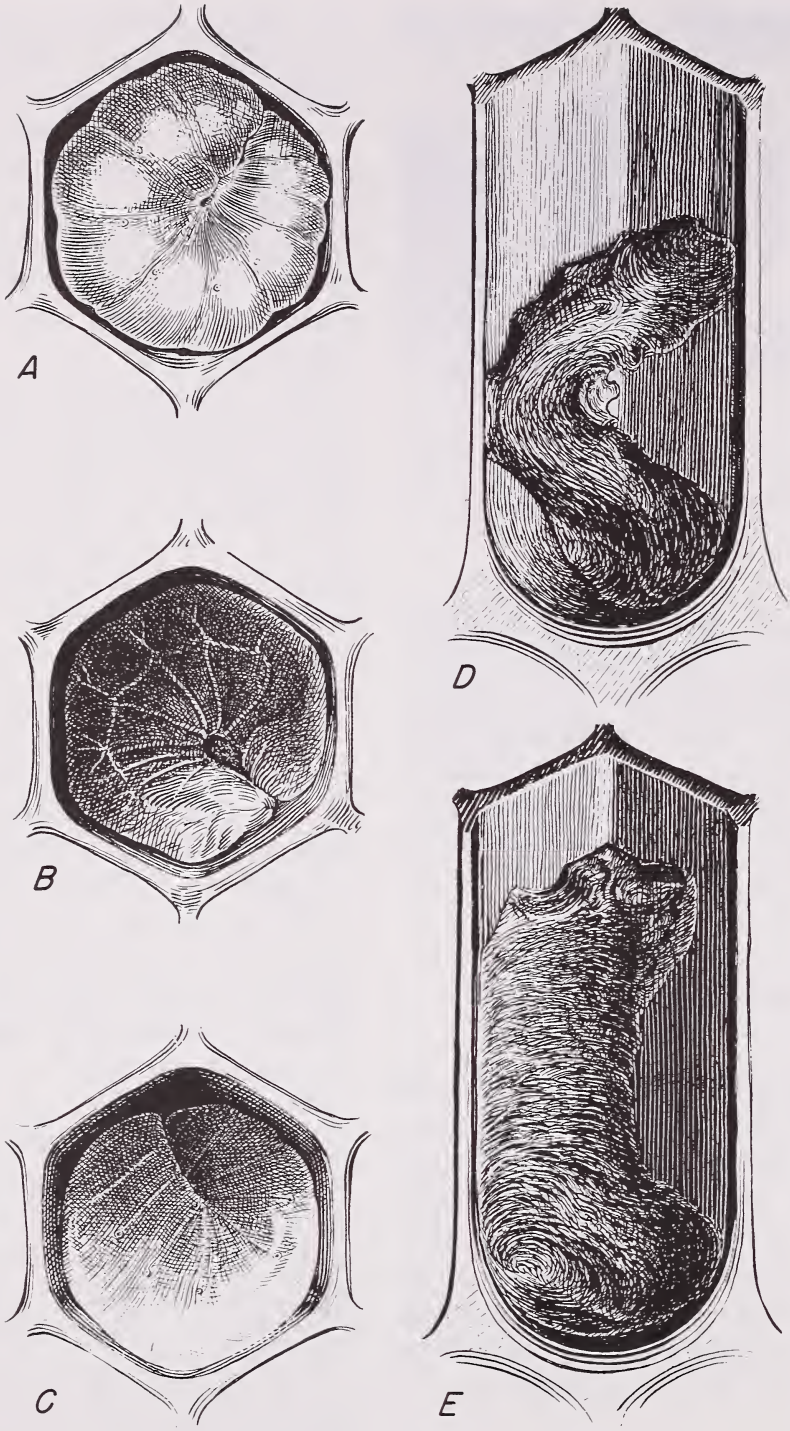

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Figure 5. Honey bee larvae killed by European foulbrood, as seen in the cells. (A) Healthy larva at earliest age when the brood dies of European foulbrood. (B) Scale formed by a dried-down larva. (C) One of several positions of sick larva prior to death. (D) and (E) Longitudinal views of scales from larvae that assumed a lengthwise position prior to death.

Recently dead larvae are rarely ropy. Scales can be removed easily from the cells and are rubbery rather than brittle as in American foulbrood.

The odor of European foulbrood varies. Typically, a sour odor is present from decayed larvae.

Spread

Spores are not formed by *Streptococcus pluton* but the organism often overwinters on combs. It gains entry into the larvae in contaminated brood food, multiplies rapidly within the gut of the larvae, and causes death about 4 days after egg hatch.

Not all infected larvae die from the disease. Sometimes larvae develop normally and void the germ, or regurgitate the bacteria onto the underside of the capping. These materials become sources of the disease.

Since the honey of infected colonies is contaminated, the disease can be spread by robber bees or by the interchange of contaminated equipment among colonies and drifting bees.

Control

In some cases, European foulbrood can be eliminated by requeening colonies with a young queen. Requeening accomplishes two things: it gives the colony a more prolific queen, and it permits a time lag between brood cycles that allows the house bees to remove diseased larvae from their cells.

Treatment.—The antibiotic oxytetracycline has been used for the prevention and control of European foulbrood. However, consult with State apiary inspectors, extension apiculturists, or State entomologists before using this drug.

Sacbrood

Cause

Sacbrood is caused by a filterable virus. This virus is so small that it cannot be seen even with the aid of a light micropscope.

Effect

Sacbrood rarely wipes out a colony of bees or becomes a serious menace to beekeeping. The disease affects both workers and drones. Pupae are killed occasionally, but adult bees are immune.

It is important for you to recognize sacbrood and distinguish it from the more serious foulbrood diseases. For a comparison of brood disease characteristics see the guide on page 10.

Sacbrood is most common during the first half of the brood-rearing season. The disease often goes unnoticed because it affects only a small percentage of brood.

Symptoms

In sacbrood, death usually occurs after the cells are first sealed. The disease rarely reaches the serious stage in which the "pepperbox" pattern becomes evident.

The larvae gradually change from pearly white to dull yellow or gray, and finally to black.

The head of the larva is the first part of the body to change

color. It becomes black. (See fig. 6.) The larva dies in an upright position.

When you remove diseased larvae from their cells and examine them, you will observe that the contents of the larvae are watery and the skin is tough and forms a sac. Hence the name: sacbrood.

The scale is gondola shaped; both the head region and posterior bend toward the center. Sacbrood scales are rough and brittle, and they loosely adhere to the cell walls.

Spread

Very little is known about the transmission of sacbrood. However, experiments employing a

Guide For Comparing Characteristics of Various Brood Diseases of Honey Bees

Characteristics to observe	*American foulbrood*	*European foulbrood*	*Sacbrood*
Appearance of brood comb.	Sealed brood. Discolored, sunken, or punctured cappings.	Unsealed brood. Some sealed brood in advanced cases with discolored, sunken, or punctured cappings.	Sealed brood. Scattered cells with punctured cappings, often with two holes.
Age of dead brood.	Usually older sealed larvae or young pupae.	Usually young unsealed larvae; occasionally older sealed larvae.	Usually older sealed larvae; occasionally young unsealed larvae.
Color of dead brood.	Dull white, becoming light brown, coffee brown to dark brown, or almost black.	Dull white, becoming yellowish white to brown, dark brown, or almost black.	Grayish or straw-colored becoming brown, grayish black, or black; head end darker.
Consistency of dead brood.	Soft, becoming sticky to ropy.	Watery to pasty; rarely sticky or ropy.	Watery and granular; tough skin forms a sac.
Odor of dead brood.	Slight to pronounced glue odor to glue-pot odor.	Slightly to penetratingly sour.	None to slightly sour.
Scale characteristics.	Uniformly lies flat on lower side of cell. Adheres tightly to cell wall. Fine, threadlike tongue of dead pupae adheres to roof of cell. Head lies flat.	Usually twisted in cell. Does not adhere tightly to cell wall. Rubbery.	Head prominently curled up. Does not adhere tightly to cell wall. Lies flat on lower side of cell. Rough texture. Brittle.

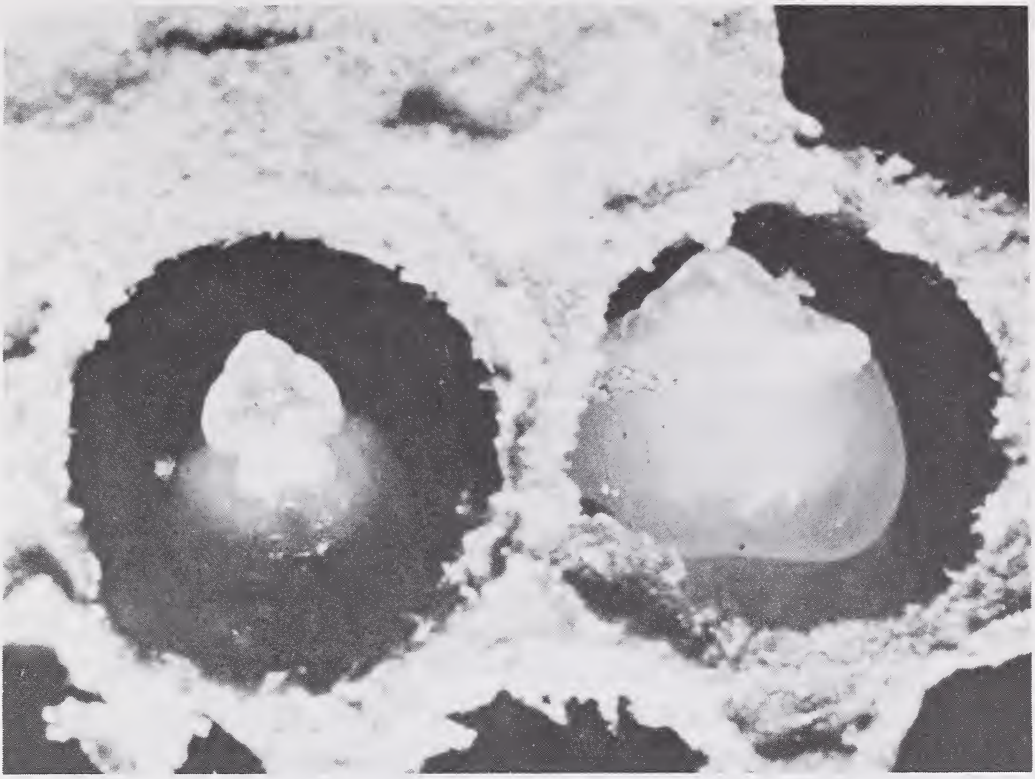

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Figure 6. In sacbrood, the larva dies in an upright position. Left: The erect head of a diseased larva. Right: The head of a healthy larva.

suspension made from diseased larvae indicate that the disease can be spread to healthy larvae through contamination of larval food.

Nurse bees are suspected of transmiting the disease by carrying the virus from cell to cell. It is also believed that robber bees spread the disease by carrying contaminated honey from colony to colony.

Control

No chemotherapeutic agent is effective in preventing or controlling sacbrood. Requeening of colonies gives some degree of success. Generally, a colony will recover from sacbrood without a beekeeper's aid.

FUNGUS DISEASES

Relatively little is known about bee diseases caused by fungi. The two most significant fungus diseases are chalkbrood and stonebrood.

Chalkbrood is caused by the fungus *Ascosphaera apis*. In 1968, the first case of chalkbrood was reported in the United States. Before then, it was solely a European problem. The disease has been reported in California,

Minnesota, Montana, and North Dakota.

Young pupae or recently sealed larvae are the most susceptible to chalkbrood. Diseased bees are usually covered with filaments that have a fluffy, cottonlike appearance. If the fungus produces spores, the diseased brood will turn gray or, sometimes, black.

Chalkbrood is seldom considered serious because it is not highly contagious. Colonies eliminate this disease without bee-keeper help.

Stonebrood is caused by the fungi belonging to the genus *Aspergillus*, primarily *A. flavus*. These fungi can be found in soil, on accumulations of dead bees, and on honeycombs.

When larvae and pupae are infected by this disease they have a green, powdery substance on their bodies. Spores form earliest and most abundantly near the head end of the dead larvae.

After dead larvae and pupae become dry, they are known as mummies. The disease is called "stone brood" because of the hard texture of the dead brood.

INFECTION WITH TWO OR MORE DISEASES

When more than one disease affects a comb it is easy to overlook a mixed infection. For example, larvae infected by American foulbrood have been found in the same comb with larvae infected by European foulbrood or sacbrood.

No single larva, however, has been found to be infected with more than one disease. Even when another disease is known to be present, make a careful search for American foulbrood. This is important when disease samples are sent for diagnosis—be sure that the sample is representative of the diseased comb.

NONINFECTIOUS DISEASES

Many beekeepers fail to recognize noninfectious diseases. Often, they assume that discolored larvae or pupae are the result of some infectious agent.

In the spring, dead adult bees and some larvae or young pupae are found at the entrance to the hives. This is not always indicative of a contagious disease; brood is often neglected because of a shortage of nurse bees and then dies from either chilling or starvation.

Typically, the center of the brood cells appear normal—only those larvae on the periphery of the combs appear abnormal. This colony condition could be caused by an infectious disease of adult bees or by toxic chemicals and is not necessarily a brood disease.

Poisonous plants can cause noninfectious diseases. Purple brood is a common disease of this type in the Southeastern United States. It is caused by either the pollen or nectar from the southern leatherwood, *Cyrilla racemiflora L.*

ADULT BEE DISEASES

Adult bee diseases are not a threat in this country, except for nosema disease. In some foreign countries, acarine disease poses a potential threat to beekeeping.

Nosema Disease

Cause

Nosema disease is caused by the protozoan *Nosema apis*. The spores of the disease are ingested by the adult bee where they germinate and multiply in the gut.

Effect

Nosema disease decreases the effective life span of adult workers and, therefore, results in a decrease in the honey harvest. Infected queens are often replaced if their egg laying capacity is affected by nosema disease. Losses in the adult population can indirectly result in neglected brood.

Nosema disease is most prevalent in the spring. This is a time when a dysenteric condition tends to be present in the colonies. In such cases nosema disease poses a serious threat. Mixed infections of *Nosema apis* and the amoeba organism, *Malpighamoeba mellificae,* are believed to be more serious than either parasite alone.

Symptoms

A microscope is required to detect the spores of *Nosema apis*. The best time for finding spores of the disease is the beginning of the flying season after winter confinement. During the summer months it is difficult to find spores in the bees. A small increase of bees infected by the disease may be found in the fall.

No single symptom typifies this disease. Affected bees make trembling movements and their wings become unhooked. Unable to fly, these bees crawl about at the entrance to the colony.

Sending Diseased Samples For Diagnosis

It is sometimes difficult to make a definite diagnosis of diseased brood and honey bees in the apiary. Diagnosis in the laboratory is a service made available to beekeepers and State apiary inspectors by the U.S. Department of Agriculture.

When you select a sample of the comb for laboratory examination for brood diseases, cut a 4-inch-square section of the comb. Make sure this piece of comb contains as much of the dead or discolored brood as possible.

If you suspect an adult bee disease, send at least 200 sick or recently dead bees in the sample. Pack this sample in a wood or strong cardboard box. Do *not* pack samples in tin, glass or plastic containers, and do not wrap either the comb or bees in waxed paper, plastic or aluminum foil.

Send all samples to the Bio-environmental Bee Laboratory, Agricultural Research Center, Beltsville, Maryland 20705. Print or type your name and address on the return label and include your Zip Code number.

The abdomen of an infected bee is often distended and appears shiny. The individual circular constrictions of a healthy bee's midintestine are visible, but in infected bees the midintestine may be swollen and the constrictions not clearly visible. (See fig. 7.)

Spread

Nosema disease can be transmitted in several ways. In overwintered colonies, confined bees infected with nosema may defecate on the combs, causing healthy bees to become infected as they clean the combs in the spring. Food stores and soiled shipping cages can also be sources of infection.

Control

The antibiotic fumagillin (Fumidil–B^{R}) has been used for the control of nosema disease. Labels for drugs carry specific instructions for their application, subject to State laws and regulations. Consult with State apiary inspectors, extension apiculturists, or State entomologists before using any chemicals.

Treatment.—To decontaminate solid bee equipment heat the equipment at 120° F. for 24 hours. This treatment will either destroy the spores or make them nonviable.

Take the following precautions when you give your equipment a heat treatment:

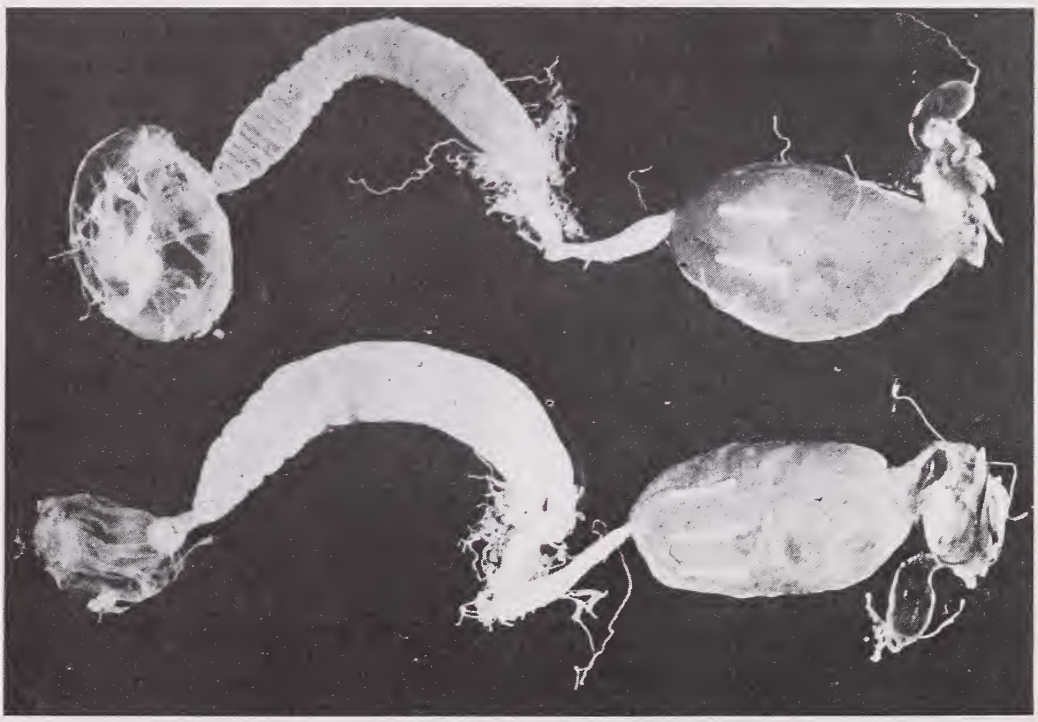

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Figure 7. Top: Digestive tract from a healthy bee. Note the individual circular constrictions on the ventriculus. Bottom: Digestive tract of a honey bee with Nosema disease. Note that the circular constrictions on the ventriculus are not clearly defined.

- Examine the combs beforehand and make sure they contain little or no honey or pollen.
- Stand the combs up so they are heated in their normal upright position (not on their sides).
- Check to see that boxes and combs have space between them that allows for air circulation.
- Never allow the temperature to exceed 120° F. or the wax will melt. Circulate the air in large rooms so no hot spots are created.

Paralysis

Cause

Paralysis of adult honey bees is a condition brought about by filterable viruses and by poisonous plants. The "paralysis" discussed here refers to the disease caused by the chronic, bee-paralysis virus.

Effect

Colonies can be affected by paralysis during the entire bee season. However, paralysis is more commonly found in warm climates. The disease affects only a small percentage of the bees. In severe cases, honey production of a colony can be seriously reduced by this virus. It is rare for colonies to be destroyed by paralysis disease.

Symptoms

Bees affected by the disease are usually found on the top bars of the combs. Individual bees tremble uncontrollably and are unable to fly. (Sick bees are sometimes attacked by healthy bees. When this condition is serious, large numbers of bees can be found crawling out of the colony entrance.) Bees with this condition are often hairless and have no control of their wings and legs. Abdomens of affected bees may be dark, shiny, or greasy.

Spread

How the virus is transmitted from bee to bee is not known. The paralysis virus is endemic in some colonies and the disease recurs each year in a small percentage of the bee population.

Control

No chemical agent for the control of paralysis is available. Infected colonies seem able to cope with the disease without medication. The offspring of some queens appear to be more susceptible than others. Consequently, requeening of affected colonies is often effective in eliminating paralysis.

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Septicemia

Septicemia is rarely considered a serious disease. Little is known about the bacterium, *Pseudo-*

monas apiseptica, that infects the bees.

Bees that die from septicemia often have a putrid odor. The muscles of the thorax decay rapidly and the body, legs, wings, and antennae fall apart when handled.

No control measure is known for this disease. The colony usually recovers spontaneously from septicemia.

Amoeba Disease

Amoeba disease is rarely found in honey bee colonies. Losses from this disease are minor except when it is found in combination with other adult diseases.

Diagnosis of this disease requires examination with a microscope. Only the cyst stage of the pathogen *Malphighamoeba mellificae* is known. The disease is believed to be transmitted through the feces.

There is no known treatment for amoeba disease. Colonies are seldom if ever destroyed by this disease.

Bee-Louse

Braula coeca, commonly known as the "bee-louse," is not a louse, but a highly specialized parasitic fly, belonging to the order Diptera. *Braula coeca* adults are wingless and incapable of flight.

The tunnels made by the bee-louse's larvae in the honey combs destroy the market value of the comb.

The bee-louse can usually be found singly or in great numbers on the bee's thorax and mouth. It literally takes food out of the mouth of the honey bee.

The bee-louse is found in limited geographical areas. It has been seen in Maryland and Virginia. No effective treatment is available for infestation by the bee-louse.

Acarine Disease

Acarine disease is not present in the United States. This disease causes serious losses of adult bees in Europe, and to some degree in South America and India. *For this reason, the importation of live adult honey bees into the United States, except from Canada, is prohibited by Federal law.* No chemical agent is approved by the Food and Drug Administration for use against acarine disease.

PREVENTING THE SPREAD OF BEE DISEASES

Bee diseases are spread when bees rob a diseased colony. For this reason good management requires that you minimize the opportunity to rob. Bee glue (propolis) and burr combs should be placed in containers which prevent the access of bees to the material. When a colony dies, close the hive to prevent the remaining stores from being robbed.

In most States, sale of equipment from colonies infected by American foulbrood is prohibited by law. Before you purchase any used equipment, be sure to consult your apiary inspector for information on the source of the equipment. As an added precaution, disinfect used equipment before use.

If you obtain adult bees or brood or feed honey (whether extracted or in combs) from unknown sources, do not add them to healthy colonies. Be certain that your source of bees and honey is from disease-free colonies. This is especially important when capturing swarms of unknown origin. When in doubt, isolate the colony until you are certain that it is disease free.

Inspect your bee colonies often. Watch for signs of disease. If any colony shows symptoms that are suspicious call your apiary inspector for his assistance, or send a test sample to a State or Federal laboratory. Instructions for sending samples are given on page 13.

USE OF PESTICIDES

Pesticide use is governed by a Federal law administered by the Environmental Protection Agency (EPA). This law requires manufacturers to register pesticides, and makes it illegal for people to use them except in accordance with the instructions on the label.

Follow label instructions carefully. You may, if you wish, use less of a pesticide than the amount permitted. Apply pesticides uniformly and be sure they come in contact ONLY with plants or areas you intend to treat.

Registrations of pesticides are under constant review by EPA. As new information is developed and evaluated, registrations may be changed or withdrawn. For the latest information on pesticides and how to use them, consult your Cooperative Extension Service or Agricultural Experiment Station in your State.

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